**D.C. DEPARTMENT OF HEALTH**
***Environmental Health Administration***
***Bureau of Environmental Quality***
***Water Quality Division***

**DISTRICT OF COLUMBIA**

# FINAL
# TOTAL MAXIMUM DAILY LOAD

# FOR

# pH

# IN

# WASHINGTON SHIP CHANNEL

**DECEMBER 2004**

Government of the
District of Columbia
Anthony A. Williams, Mayor

**DISTRICT OF COLUMBIA**

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## INTRODUCTION

Section 303(d) (1)(A) of the Federal Clean Water Act (CWA) states:

> *Each state shall identify those waters within its boundaries for which the effluent limitations required by section 301(b) (1)(A) and section 301(b)(1)(B) are not stringent enough to implement any water quality standards applicable to such waters. The State shall establish a priority ranking for such waters taking into account the severity of the pollution and the uses to be made of such waters.*

Further, Section 303(d) (1)(C) states:

> *Each state shall establish for the waters identified in paragraph (1)(A) of this subsection, and in accordance with the priority ranking, the total maximum daily load, for those pollutants which the Administrator identifies under section 304(a)(2) as suitable for such calculations. Such load shall be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality.*

Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies, which are exceeding water quality standards.

In 1996, the District of Columbia (DC), developed a list of impaired waters that did not or were not expected to meet water quality standards as required by Section 303(d)(1)(A). This list, submitted to the Environmental Protection Agency every two years, is known as the Section 303(d) list. This list of impaired waters was revised in 1998 and 2002 based on additional water quality monitoring data. EPA, subsequently, approved each list. The Section 303(d) list of impaired waters contains a priority list of those waters that are the most polluted. This priority listing is used to determine which waterbodies are in critical need of immediate attention. For each of the listed waters, states are required to develop a Total Maximum Daily Load (TMDL), which establishes the maximum amount of a pollutant that a waterbody can receive without violating water quality standards and allocates that load to all significant sources. Pollutants above the allocated loads must be eliminated. By following the TMDL process, states can establish water-quality based controls to reduce pollution from both point and non-point sources to restore and maintain the quality of their water resources. The Washington Ship Channel experiences occasional high pH conditions and is listed on DC’s 303(d) lists because of violations of water quality standards for pH.

## DESIGNATED BENEFICIAL USES AND APPLICABLE D.C.WATER QUALITY STANDARDS

Categories of DC surface water designated beneficial uses and water quality standards are contained in District of Columbia Water Quality Standards, Title 21 of the District of Columbia Municipal Regulations, Chapter 11 (DC WQS, Effective January 24, 2003). Section 1101.1 states:

*For the purposes of water quality standards, the surface waters of the District shall be classified on the basis of their (i) current uses, and (ii) future uses to which the waters will be restored.*

The categories of beneficial uses that were used to determine Water Quality standards for the surface waters of the District of Columbia are as follows:

| Category of Use | Class of Water |
|---|---|
| Primary contact recreation…………………………………………… | A |
| Secondary contact recreation and aesthetic enjoyment………………… | B |
| Protection and propagation of fish, shellfish, and wildlife …………….. | C |
| Protection of human health related to consumption of fish and shellfish | D |
| Navigation ……………………………………………………………… | E |

The table below identifies the current use and designated beneficial uses in Washington Ship Channel.

| Waterbody | Current Use | | | | | Designated Use | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | A | B | C | D | E |
| Washington Ship Channel | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

Where, Current use means the use which is generally and usually met in the waterbody at the present time in spite of the numeric criteria for that use not being met sometimes; and Designated use means the use specified for the waterbody in the water quality standards whether or not it is being attained.

**Narrative Criteria**

The District of Columbia's Water Quality Standards include narrative and numeric criteria that were written to protect existing and designated uses.

Section 1104.1 states several narrative criteria designed to protect the existing and designated uses:

*The surface waters of the District shall be free from substances attributable to point or nonpoint sources discharged in amounts that do any one of the following:*

1. *Settle to form objectionable deposits;*
2. *Float as debris, scum, oil, or other matter to form nuisances;*
3. *Produce objectionable odor, color, taste, or turbidity;*
4. *Cause injury to, are toxic to or produce adverse physiological or behavioral changes in humans, plants, or animals;*
5. *Produce undesirable or nuisance aquatic life or result in the dominance of nuisance species; or*
6. *Impair the biological community which naturally occurs in the waters or depends on the waters for their survival and propagation.*

**Numerical Criteria**

| Constituent | Criteria for Classes | | |
|---|---|---|---|
| | A | B | C |
| pH Greater than<br>And Less Than | 6.0<br>8.5 | 6.0<br>8.5 | 6.0<br>8.5 |

## WATERSHED

The Washington Ship channel along with the Tidal Basin are man-made waterbodies located in the southwest section of Washington D.C. along the Potomac River. The Tidal Basin was built in the late 19th century by the Army Corps of Engineers as a part of the comprehensive management of the Potomac River and land development of Washington D.C. The main function of the Tidal Basin is to flush the Washington Ship Channel with the freshwater from the Potomac River. Two sets of floodgates exist in the flushing system, one linking the Tidal Basin and the Potomac River, and the other linking the Tidal Basin and the Washington Ship Channel. Freshwater flows into the Tidal Basin through the flap gates when the tidal elevation changes and the elevation in the Potomac River is higher than that in the Tidal Basin. In the same way, the freshwater flushes into the Washington Ship Channel as the water surface elevation becomes higher in the Tidal Basin. The purpose of the gates is to direct flow from the Potomac River to the Tidal Basin then to the Washington Ship Channel. The Tidal Basin is shallow with an average depth of around 6.5 feet (2 meters) and a surface area of about 0.15 square miles (0.4 km2). The Washington Ship Channel is about 400 feet (122 meters) wide and the depth varies from 3 feet (1 meter) to 26 feet (8 meter) (Velinsky et al. 1994). Figure 1 shows the Washington Ship Channel and the Tidal Basin.

The land use around the Washington Ship Channel is dominated by government/commercial/residential uses along the northern bank of the waterbody covering about 53 percent of the watershed (see Figure 2). The area along the southern bank is characterized by recreational grass and parklands, with the Channel itself covering about 25 percent of the watershed. The channel, along the northern banks between the Tidal Basin and Fort McNair, is used as docking for small personal and large commercial touring boats. There is a large fish market and series of seafood restaurants along the docking areas.

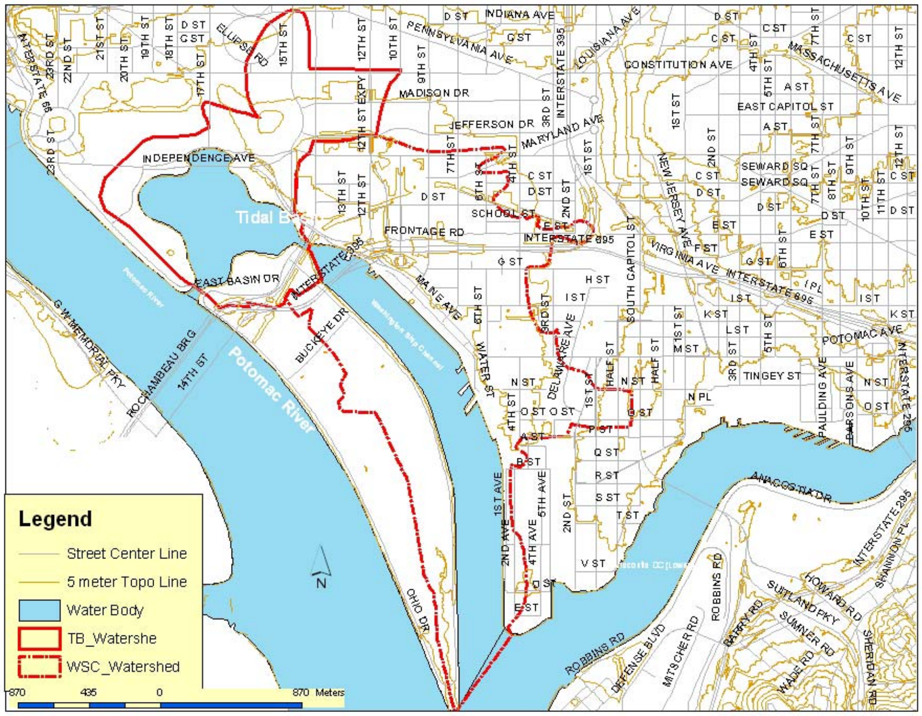


Figure 1: Tidal Basin and Washington Ship Channel

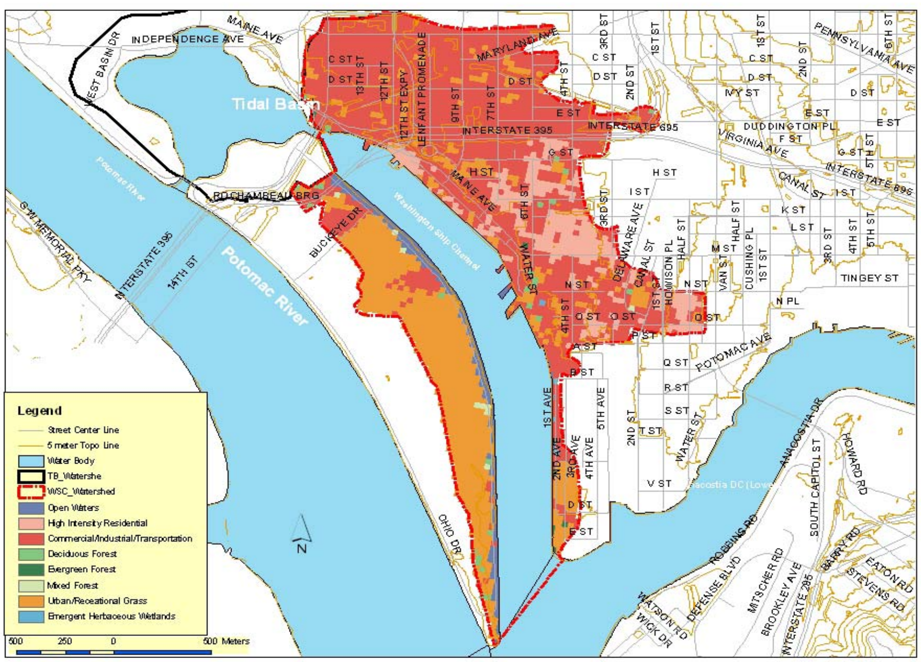


Figure 2: Landuse in the Washington Ship Channel Watershed

## SOURCE ASSESSMENT

Within the District of Columbia, there are three different networks for conveying wastewater. Originally, a combined sewer system was installed which collected sanitary waste and storm water and transported the sanitary flow to the wastewater treatment plant. When storm water causes the combined flow to exceed the capacity of the treatment plant, the excess flow is discharged, untreated, through the combined sewer overflow to the rivers. Approximately one third of the District of Columbia is served by the combined sewer system. The remaining two thirds of the District of Columbia is served by a separate system where one pipe network (separate sanitary sewage system) collects sanitary sewage that is transported to the Blue Plains wastewater treatment plant in the southeast corner of the District and another pipe network (separate storm sewer system) collects storm water that is transported and discharged to the nearest stream channel.

The Washington Ship Channel is served by the separate storm system as shown in Figure 3. There are no combined sewer outfalls in the waterbody. Separate storm water networks collect storm water from streets and parking lots. Collected storm runoffs are then directly discharged to the Channel. There are nine storm sewers discharging into the Washington Ship Channel.

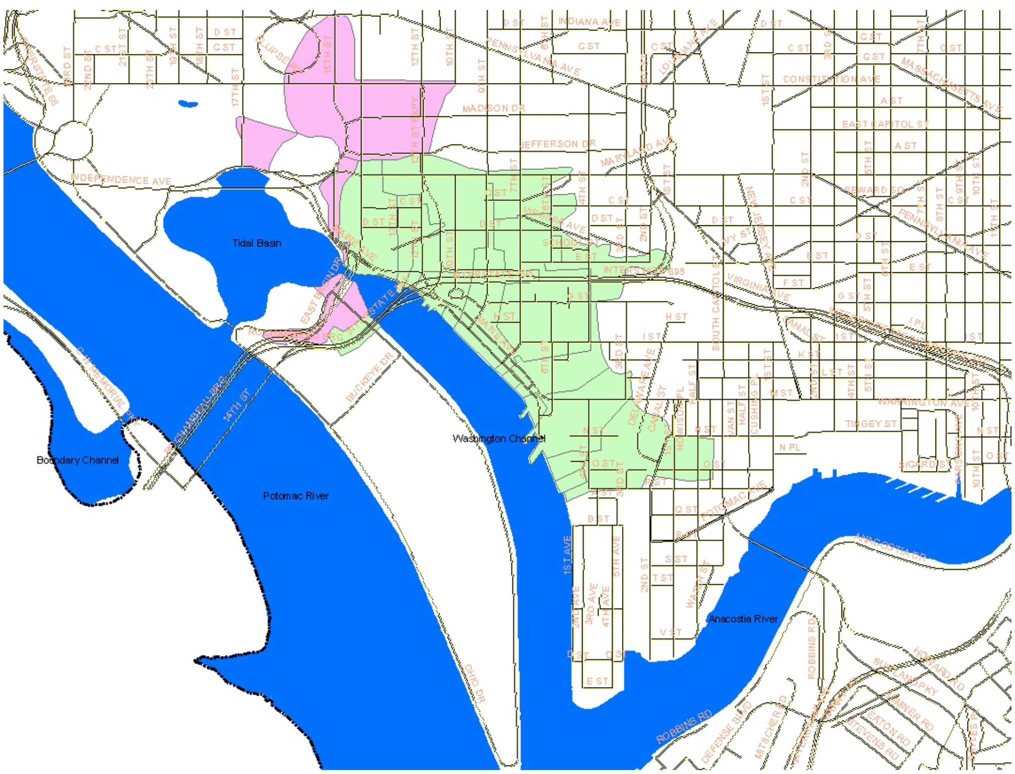


Figure 3. Separate Storm Sewer Areas in the Tidal Basin and Washington Ship Channel Watersheds

Direct runoffs from parklands flanking the water bodies and not serviced by storm water sewers also occur along the Washington Ship Channel. Therefore, during wet weather events, there is a combination of direct storm water runoff and storm water being carried by pipes to the Channel. Historically considered nonpoint source, storm water runoff discharged from separate storm sewer systems (SSWS) are permitted under the National Pollution Discharge Elimination System (NPDES).

The Washington Ship Channel exhibits occasional high pH, in exceedance of the water quality criterion of 8.5 standard units. In addition to storm and direct runoffs, because of direct hydraulic connections, the Washington Ship Channel is affected by the water quality conditions in the Potomac and Anacostia Rivers.

## TMDL ANALYTICAL APPROACH

pH is a measure of the relative acidity or alkalinity of water as well as a measure of the hydrogen ion concentration in water. The pH is defined as the negative logarithm of the hydrogen ion concentration in terms of moles per liter.

$$pH = -\log [H+]$$

Water with a pH of 7 is neutral; lower pH levels indicate increasing acidity, while pH levels higher than 7 indicate increasingly basic solutions. pH values can range from 1.0 for a very acidic solution to 14.0 for a very basic solution.

The goal of the TMDL is to achieve a pH concentration that allows for meeting of water quality standards and sustainability of aquatic life and designated uses. There are no known point sources in the watershed that would cause high pH. As Municipal Separate Storm Sewer System (MS4) monitoring data in the District of Columbia indicates, urban storm water runoffs are generally acidic and cannot be the cause of high pH impairments. However, excessive nutrients in the water can cause high pH due to algal activities. The pH and Chlorophyll A data in the ship channel were analyzed and a linear regression curve was developed as shown in Figure 4. This is similar to pH versus Chlorophyll A relationships observed in the main-stem Potomac River during the 1983 algal bloom period as shown in Figures 5 and 6 (Thomann, 1985). From the analysis, it can be concluded that pH exceedances in the Ship Channel are related to algal activities (measured as Chlorophyll A). Using these regression relationships, Chlorophyll A that will achieve compliance with the pH criteria thus can be calculated.

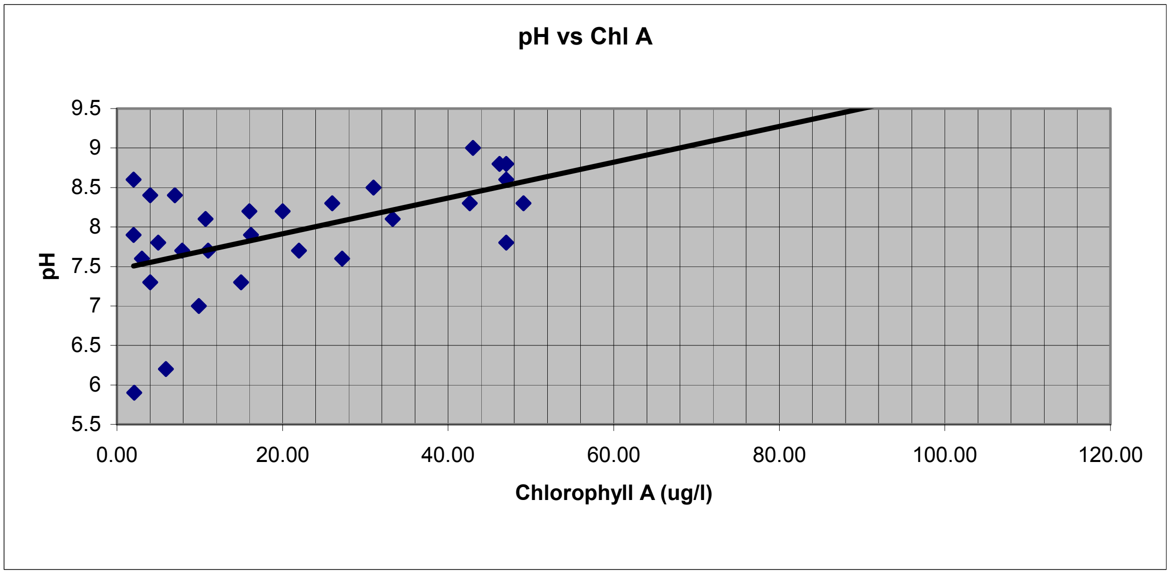


Figure 4: pH vs Chlorophyll A in Washington Ship Channel (1999-2001)

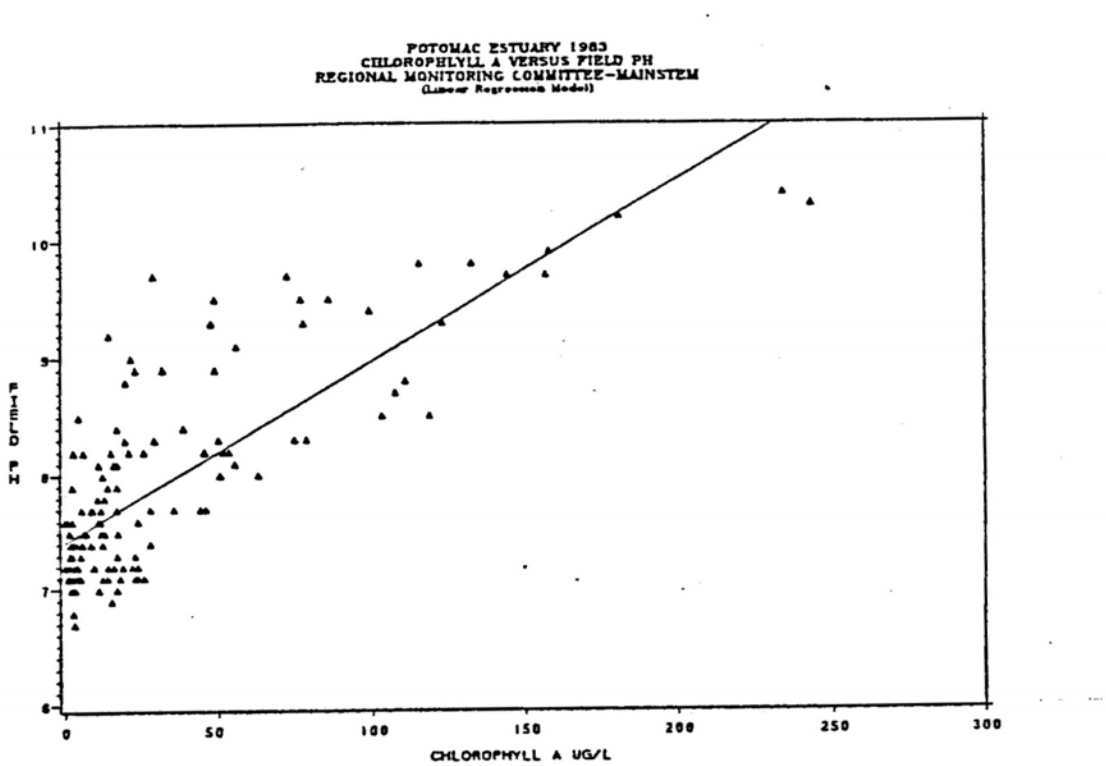


Figure 5: Chlorophyll A vs Field pH in Main-Stem Potomac (Thomann, 1985)

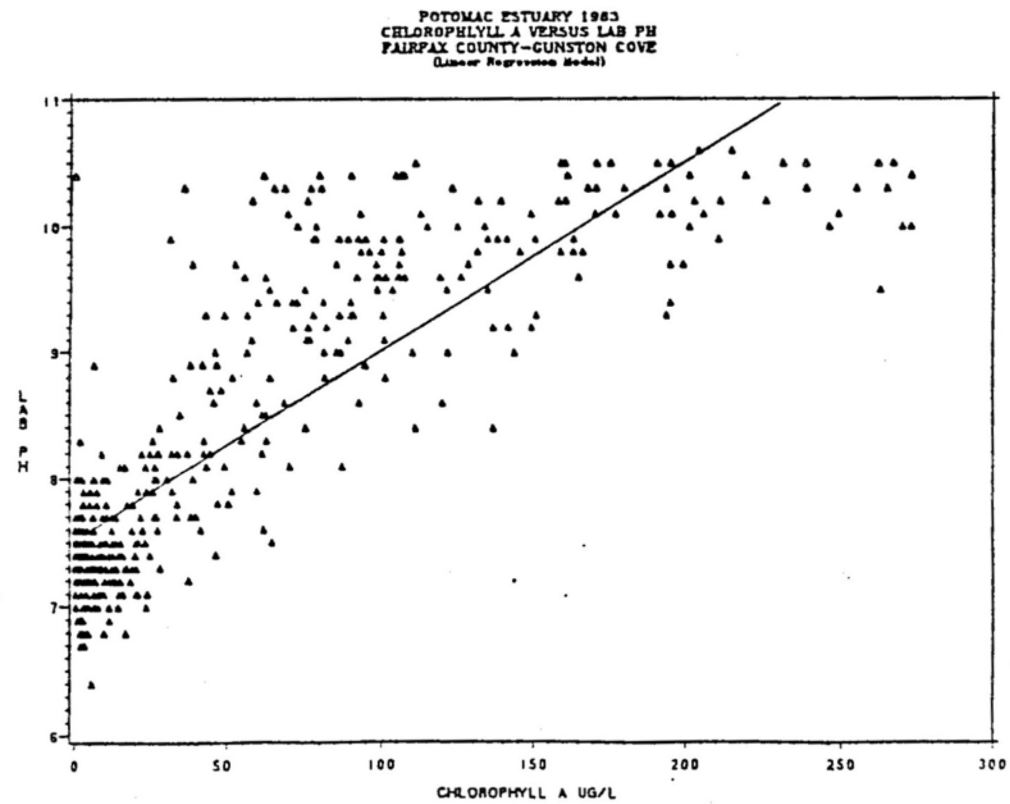


Figure 5: Chlorophyll A vs Lab pH in the Potomac (Gunston Cove) (Thomann, 1985)

As excessive nutrients promote a number of undesirable water quality conditions such as algal growth, low dissolved oxygen and reduced water clarity, the U.S. EPA Chesapeake Bay Program has conducted numerous modeling studies in the Bay as a part of the nutrient reduction strategies. The Chesapeake 2000 agreement committed its signatories (includes Maryland, Pennsylvania, Virginia, and the District of Columbia) to "*continue efforts to achieve and maintain the 40 percent nutrient reduction goal agreed to in 1987 and correct the nutrient- and sediment-related problems in the Chesapeake Bay and its tidal tributaries sufficiently to remove the Bay and the tidal portions of its tributaries from the list of impaired waters under the Clean Water Act* by 2010". The Chesapeake Bay partners have agreed to nutrient loading caps for the entire Bay (see Memo to Principal Staffs Committee, 2003 in Appendix B). These allocations are projected to eliminate excessive algae conditions (measured as Chlorophyll A) throughout the Chesapeake Bay and its tidal tributaries (USEPA, 2003).

The Chesapeake Bay water quality modeling analysis shows that summer average Chlorophyll A concentration of 17.59 ug/l (high concentrations usually occur during the summer) is achieved in the Tidal Fresh Potomac under the allocated nutrient caps (personal communication with USEPA Chesapeake Bay Program, see Appendix A). Assuming the Washington Ship Channel an integral part of the Potomac river system, it can be considered that the same average Chlorophyll A concentration can also be achieved in the Ship Channel under the allocated nutrient loads. In order to determine if the pH standards can be achieved under peaking conditions, the peak Chlorophyll A concentration was calculated using average to peak ratio of the observed data in the Ship Channel. The peak Chlorophyll A concentration was then used to determine the pH in the Channel using the regression curves described earlier. Evaluation of attainment of the pH standard in the Ship Channel is described in the following:

| | |
|---|---|
| Observed Average Chlorophyll A in the Ship Channel = | 20.80 ug/l |
| Observed Peak Chlorophyll A in the Ship Channel = | 49.10 ug/l |
| Observed Peak to Average Ratio = | 2.36 |

Summer Average Chlorophyll A in the Potomac River for the allocation/confirmation scenario = 17.59 ug/l

Peak Chlorophyll A in the Ship Channel = 17.59X 2.36= 41.53 ug/l

Using Figure 4, pH for the peak Chlorophyll A = 8.4

Using Figure 5, pH for the peak Chlorophyll A = 8.1

Using Figure 6, pH for the peak Chlorophyll A = 8.15

Therfore, using the all three relationships, it can be demonstrated that the pH in the Washington Ship Channel will be less than 8.5 and meet the DC water quality standard under the Chesapeake Bay confirmation scenario.

According to the Chesapeake Bay water quality modeling analysis, the upper Potomac River is phosphorous limited. The District of Columbia has already achieved its phosphorous reduction goal under the Bay allocation. However, unless upstream nutrients loads are reduced, the Potomac River and the Ship Channel will be affected by nutrient enrichments and related water quality impairments. As the District of Columbia has already met its goals for phosphorous, the increased algal activities and related high pH conditions in the Ship Channel can be directly attributed to the upstream loads.

## TOTAL MAXIMUM DAILY LOAD AND ALLOCATION

### Wasteload and Load Allocation, and Margin of Safety

As noted earlier, the Chesapeake Bay water quality model analysis shows that the upper Potomac River is phosphorous limited. The Chesapeake Bay partners have agreed to reductions of phosphorous loads to the allocated caps in the confirmation scenario (Memo to Principal Staffs Committee, 2003 in Appendix B). According to the Bay program model analysis, phosphorous loads at the Potomac Fall Line are 3.25 million-pounds/per year and 2.32 million-pounds/per year for the “2000 Progress” and the “Confirmation” scenarios, respectively (personal communication with USEPA Chesapeake Bay Program, see Appendix A). Therefore, a reduction of 28.6 percent of the fall line phosphorous load is needed to achieve the necessary chlorophyll A concentrations, hence the pH standard, in the Washington Ship Channel. No reductions of phosphorous loads are needed in the District of Columbia. An explicit margin of safety was not considered because of various conservative assumptions included in the modeling. Existing and allocated loads for phosphorous are summarized in the following table.

Existing and Allocated Loads for Phosphorous in Washington Ship Channel (pounds per average year)

| **Sources** | **Existing** | **TMDL** | **Percent Reduction** |
|---|---|---|---|
| Upstream | 3,246,530 | 2,323,964 | 28.42% |
| Storm Water (DC) | 394 | 977 | No reduction needed |
| Direct Runoff (DC) | 165 | 408 | No reduction needed |

## SEASONAL VARIATIONS AND CRITICAL CONDITIONS

The Chesapeake Bay water quality model was run for a wide range of weather conditions over a number of years (1985 through 1994). Therefore, the analysis takes into account various environmental conditions.

## REASONABLE ASSURANCE

Maryland, Virginia, Pennsylvania and West Virginia tributary strategies will achieve the upstream phosphorous reductions needed. Tributary Strategies are river-specific cleanup strategies that include plans and actions needed to reduce the amount of nutrients and sediment flowing into the Chesapeake Bay and its tributaries.

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Velinsky, D., Wade, T.L., Schlekat, C.E., Presley, B.J., 1994. Tidal River Sediments in the Washington, D.C. Area. 1. Distribution and Sources of Trace Metals. *Estuaries*, (17) 305-320

# APPENDIX A

## Chesapeake Bay Water Quality Modeling Results

(source: personal communication with USEPA Chesapeake Bay Program)

-----Original Message-----
From: Ping Wang [mailto:PWang@chesapeakebay.net]
Sent: Tuesday, December 07, 2004 1:22 PM
To: Chowdhury, Monir (DOH)
Cc: Lewis Linker
Subject: RE: Need info- Chlorophyll a concentration in the Upper Potomac

Monir,

Per our phone conversation, the following is what you requested:

The 10 year (1985-1994) average spring (March, April, May) and summer (July, August, September) surface chlorophyll concentration in Potomac Tidal Fresh from the Confirmation Scenario is:

7.74 ug/L and 17.59 ug/L, respectively.

Note: the data was retrieved directly from the model outputs for the surface model cells in POTTF.

Please let me know if you need additional information.

Cheers,
Ping

## Fall Line Phosphorous Loads

-----Original Message-----
From: Ping Wang [mailto:PWang@chesapeakebay.net]
Sent: Thursday, December 09, 2004 12:20 PM
To: Chowdhury, Monir (DOH)
Cc: Lewis Linker
Subject: RE: Potomac falline

Hi Monir,

Sorry, that was for all above fallline. For Potomac fall line, they are 3,246,530 and 2,323,964 for the 2 scenarios.

Ping

-----Original Message-----
From: Ping Wang [mailto:PWang@chesapeakebay.net]
Sent: Thursday, December 09, 2004 11:41 AM
To: Chowdhury, Monir (DOH)
Cc: Lewis Linker; Jeff Sweeney
Subject: RE: Potomac falline

Monir,
The 10 year average of Potomac above fallline TP loads for PR2000 scenario and confirmation scenario are: 11,454,593 and 7,530,395 (pounds/year)

Ping

# APPENDIX B